CLAIMS

1. A DC converter comprising:

a first series circuit being connected in parallel with a DC power source and including a primary winding of a transformer and a first switch that are connected in series;

a saturable reactor connected in parallel with the primary winding of the transformer;

a first return circuit being connected to the first series circuit and including a second switch and a snubber capacitor that are connected in series, to return energy accumulated in the saturable reactor;

a rectifying/smoothing circuit connected in parallel with a secondary winding of the transformer and including a rectifying element and a smoothing element; and

a control circuit to turn on and off the first and second switches alternately.

2. The DC converter of claim 1 further comprising:

a power supply source to accumulate power when the first switch is ON and supply the power to the snubber capacitor when the first switch is OFF,

the first return circuit being connected in parallel with any one of the first switch and primary winding,

the control circuit turning off the second switch when a current to the second switch increases.

3. The DC converter of claim 2, wherein the saturable reactor is realized by using the saturation characteristic of a core of the transformer.

4. The DC converter of claim 2, wherein the power supply

source comprises a second series circuit connected to a first end of the DC power source and a node between the first switch and the second switch and including a first reactor and a diode that are connected in series.

5. The DC converter of claim 2, wherein the power supply source comprises a second reactor connected in series between the DC power source and the primary winding of the transformer.

6. The DC converter of claim 5, wherein the second reactor comprises a leakage inductor of the transformer.

7. The DC converter of claim 4 or claim 5, wherein the secondary winding of the transformer comprises a plurality of secondary windings that are wound around a core of the transformer and are separated away from each other, each of the secondary windings being provided with the rectifying/smoothing circuit having the rectifying element and smoothing element.

8. The DC converter of claim 7, wherein the primary winding of the transformer is loosely coupled with each of the secondary windings, and the secondary windings are tightly coupled with each other.

9. The DC converter of claim 2, wherein a magnetic path of a core of the transformer is locally provided with a cross-sectional-area-reduced part.

10. The DC converter of claim 2, wherein:

the DC power source comprises an AC power source and an input rectifying circuit connected to the AC power source to rectify an AC voltage;

a series circuit is connected between a first output terminal and a second output terminal of the input rectifying circuit, the series circuit comprising an input smoothing capacitor and a rush current limiting resistor that is connected in series with the input smoothing capacitor, to reduce a rush current of the input smoothing capacitor when the AC power source is turned on;

the first switch comprises a normally-ON-type switch that is connected through the primary winding of the transformer to the first output terminal of the input rectifying circuit; and

the control circuit turns off the first switch with a voltage generated by the rush current limiting resistor when the AC power source is turned on, and after the input smoothing capacitor is charged, starts a switching operation to turn on and off the first switch.

11. The DC converter of claim 10, wherein the transformer further includes an auxiliary winding, and the DC converter further comprises a normal operation power source to supply a voltage generated by the auxiliary winding of the transformer to the control circuit.

12. The DC converter of claim 10, further comprising:

a semiconductor switch connected in parallel with the rush current limiting resistor,

the control circuit turning on the semiconductor switch after starting the switching operation of the first switch.

13. The DC converter of claim 1, wherein:

the first switch of the first series circuit is connected through a third reactor to the primary winding; and

a second return circuit is connected to the transformer, to return energy accumulated in the third reactor to the secondary

side of the transformer.

14. The DC converter of claim 13, wherein the second return circuit includes an auxiliary transformer connected in series with the transformer, to return the energy accumulated in the third reactor when the first switch is ON to the secondary side when the first switch is OFF.

15. The DC converter of claim 14, further comprising:

a power supply source to accumulate power when the first switch is ON and supply the power to the snubber capacitor when the first switch is OFF,

the first return circuit being connected in parallel with any one of the first switch and primary winding, and

the control circuit turning off the second switch when a current to the second switch increases.

16. The DC converter of claim 14, wherein the third reactor comprises a leakage inductor between the primary winding and secondary winding of the transformer that are loosely coupled around a core of the transformer, the primary winding of the transformer and the secondary winding of the auxiliary transformer being wound around the core of the transformer and being tightly coupled with each other.

17. The DC converter of claim 13, wherein the saturable reactor is realized by the saturation characteristic of a core of the transformer.

18. The DC converter of claim 15, wherein the power supply source comprises a second series circuit connected to a first end of the DC power source and a node between the first switch and the

second switch and including a first reactor and a diode that are connected in series.

19. The DC converter of claim 15, wherein the power supply source comprises a second reactor connected in series with the primary winding of the transformer.

20. The DC converter of claim 19, wherein the second reactor comprises a leakage inductor of the transformer.

21. The DC converter of claim 13, wherein at least one tertiary winding is wound around a core of the transformer and is loosely coupled with the primary winding of the transformer, and each of the tertiary windings is provided with the rectifying/smoothing circuit having the rectifying element and smoothing element.

22. The DC converter of claim 13, wherein a magnetic path of a core of the transformer is locally provided with a cross-sectional-area-reduced part.

23. The DC converter of claim 14, wherein the rectifying/smoothing circuit further comprises:

a third switch connected to a node between a first end of the secondary winding of the transformer and a first end of a secondary winding of the auxiliary transformer and to a first end of the smoothing element, a control terminal of the third switch being connected to a second end of the secondary winding of the auxiliary transformer; and

a fourth switch connected to the second end of the secondary winding of the auxiliary transformer and the first end of the smoothing element, a control terminal of the fourth switch being connected to the first end of the secondary winding of the auxiliary

transformer.

24. The DC converter of claim 13, wherein:

the DC power source comprises an AC power source and an input rectifying circuit connected to the AC power source to rectify an AC voltage;

a series circuit is connected between a first output terminal and a second output terminal of the input rectifying circuit, the series circuit comprising an input smoothing capacitor and a rush current limiting resistor that is connected in series with the input smoothing capacitor, to reduce a rush current of the input smoothing capacitor when the AC power source is turned on;

the first switch comprises a normally-ON-type switch that is connected through the primary winding of the transformer to the first output terminal of the input rectifying circuit; and

the control circuit turns off the first switch with a voltage generated by the rush current limiting resistor when the AC power source is turned on, and after the input smoothing capacitor is charged, starts a switching operation to turn on and off the first switch.

25. The DC converter of claim 24, wherein the transformer further includes an auxiliary winding, and the DC converter further comprises a normal operation power source to supply a voltage generated by the auxiliary winding of the transformer to the control circuit.

26. The DC converter of claim 24, further comprising:

a semiconductor switch connected in parallel with the rush current limiting resistor,

the control circuit turning on the semiconductor switch after starting the switching operation of the first switch.

27. The DC converter of claim 1, further comprising:

a power supply source to accumulate power when the first switch is ON and supplies the power to the snubber capacitor when the first switch is OFF,

the first return circuit being connected in parallel with any one of the first switch and primary winding,

the rectifying/smoothing circuit including a second rectifying element connected in parallel with the secondary winding of the transformer through the rectifying element and a fourth reactor connected between the rectifying element and the smoothing element,

the control circuit turning off the second switch when a current to the second switch increases.

28. The DC converter of claim 1, further comprising:

a power supply source to accumulate power when the first switch is ON and supplies the power to the snubber capacitor when the first switch is OFF,

the first return circuit being connected in parallel with any one of the first switch and primary winding,

the rectifying/smoothing circuit including:

a fourth reactor connected between the smoothing element and the secondary winding of the transformer;

a third switch connected in parallel with the rectifying element and having a control terminal connected to a second end of the secondary winding and a fourth switch connected in parallel with a series circuit of the third switch and secondary winding and having a control terminal connected to a first end of the secondary winding; and

a second rectifying element connected in parallel with the secondary winding of the transformer through the third switch,

the control circuit turning off the second switch when a

current to the second switch increases.

29. The DC converter of claim 27 or claim 28, wherein the saturable reactor is realized by using the saturation characteristic of a core of the transformer.

30. The DC converter of claim 27 or claim 28, wherein the power supply source comprises a second series circuit connected to a first end of the DC power source and a node between the first switch and the second switch and including a first reactor and a diode that are connected in series.

31. The DC converter of claim 27 or claim 28, wherein the power supply source comprises a second reactor connected in series between the DC power source and the primary winding of the transformer.

32. The DC converter of claim 33, wherein the second reactor comprises a leakage inductor of the transformer.

33. The DC converter of claim 27 or claim 28, wherein a magnetic path of a core of the transformer is locally provided with a cross-sectional-area-reduced part.

34. The DC converter of claim 1, wherein the control circuit turns on the first switch within a predetermined period from the time when the voltage of the first switch becomes zero due to resonance between a resonant capacitor connected in parallel with the first switch and the saturation inductance of the saturable reactor.